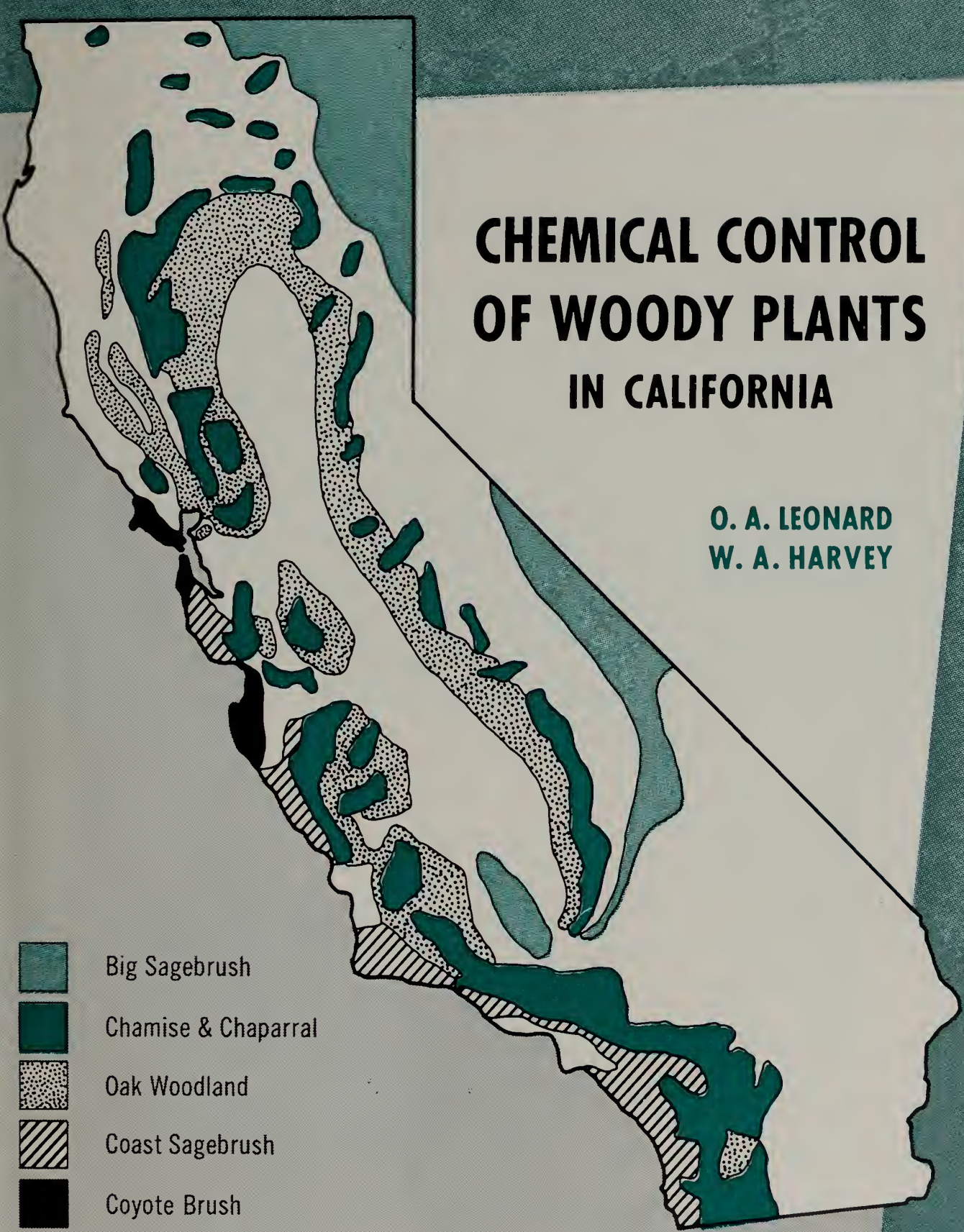




CHEMICAL CONTROL OF WOODY PLANTS IN CALIFORNIA

O. A. LEONARD
W. A. HARVEY

- 
- The map of California is divided into regions representing different types of woody plants. The distribution is as follows: Big Sagebrush (light green) is found in the northern and central mountainous regions. Chamise & Chaparral (dark green) is found in the coastal and southern regions. Oak Woodland (dotted pattern) is found in the central and southern regions. Coast Sagebrush (diagonal lines) is found along the southern coast. Coyote Brush (solid black) is found in small patches in the central and southern regions.
- Big Sagebrush
 - Chamise & Chaparral
 - Oak Woodland
 - Coast Sagebrush
 - Coyote Brush



$\frac{1}{4}$ of California's land

Over one-fourth of California land—nearly 27 million acres of so-called range land—is partly or completely occupied by brush and trees of little if any economic value, including chamise and other chaparral, coyote brush, live oak, digger pine, coast sage, and big sagebrush. Another quarter of the State is taken up by forests;

Control of woody plants by the use of chemicals is therefore of concern to all—particularly to ranchers, lumber com-

panies, tree farms, U. S. and State Forests, and all groups both private and governmental who have rights of way to maintain. Range improvement, erosion control, access to spring and well water, irrigation, and highway maintenance are all directly involved.

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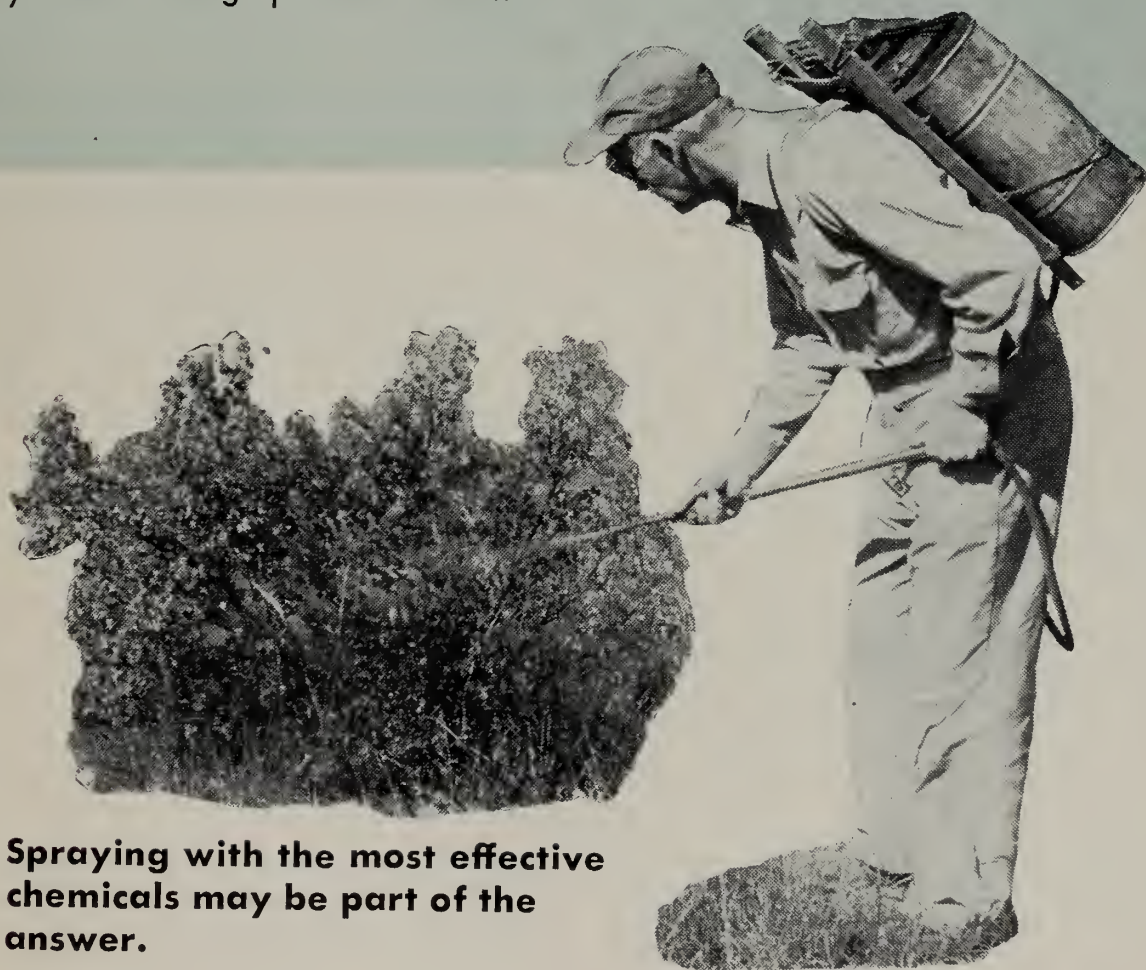
as low economic value

here too woody plants ("underbrush") are an important problem. In sugar pine forests chemical control of the many varieties of wild currant and gooseberry (ribes) is necessary to destroy the white pine blister rust, for which they serve as alternate hosts. Ceanothus, besides serv-

ing as a host for ticks, often makes an almost impenetrable jungle for the hunter and fisherman. Willows along stream banks hinder stream-bed maintenance and make flood control (and mosquito control) difficult, if not impossible. Poison oak is a menace to most California residents.

This bulletin describes the chemicals now in use—2,4-D, 2,4,5-T, Ammate, and Amino triazole—their diluting agents, the methods of application, and the equipment needed. (Wherever the term "brush killer" is used it refers to a mixture of 2,4-D and 2,4,5-T.) The discussion is followed by tables listing specific reactions

of plants to the chemicals used. The second half of the book is taken up with tests made and results obtained on the various plants, with exact recommendations, wherever possible, of kind and amount of chemical and method of application.



Spraying with the most effective chemicals may be part of the answer.

Have you a brush problem?

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If your problem...

is to control brush in range or forest lands; in drainage areas; or along roads and rights of way . . .

you share with thousands of others the need to know the most economical materials to use and the surest method of application. The use of chemicals for this purpose has developed mostly as a result of the discovery of the 2,4-D type of hormone (or growth-regulating) chemicals. Extensive chemical control of woody plants developed east of the Rockies in the late 40's, and has developed in California since then.

A variety of interests can be served by the use of chemicals for the control of brush. Along telephone and power lines and railroad rights of way, experimental work has shown that the cost of chemical control is less than that involved in mechanical brush removal. The practice of spraying these areas with chemicals, long established in the eastern and southern states, is now on the increase in California.

Ranchers will be interested in chemical control for (1) reducing brush encroachment on cleared range land; (2) reclaiming valueless brush land by transforming it into good pasture; (3) controlling brush and trees around springs and along water courses to release more water for livestock and domestic use; and (4) making more water available for irrigation by large-scale control of woody plants. It has been noted that springs have started flowing following controlled burns. (See "Brush Control in California," referred to in Literature Cited, p. 40.)

In California, about 27 million acres are relatively worthless because of infestation by woody plants: Commercial forest land that is little more than brush

occupies about 2,500,000 acres. In 7,500,000 acres of woodland grass, brush is becoming a problem. There are 7,300,000 acres of chamise; 2,400,000 acres of chaparral other than chamise; 2,250,000 acres of coast sage and sagebrush; and 5,000,000 acres of big sagebrush.

Chemical methods may be used on forest lands for all of the following purposes:

(1) for pest control. A very important problem in California is the white pine blister rust. Wild currants and gooseberries (ribes) are alternate hosts for this rust; and their removal in the important sugar- and white-pine growing areas is necessary if these trees are to be saved from virtual extinction. Control of ribes in park lands is also desirable to save the five-needle pines within these areas.

(2) to make successful plantings of small trees from nurseries. Bear clover (mountain misery) and manzanita greatly influence the survival of the planted trees.

(3) to check the spread of Scotch broom. This escaped ornamental interferes with natural pine reproduction.

(4) to reduce the numbers of trees of small economic value in forested areas. Examples are madrone, black oak, and tan oak.

(5) to shift from one species of woody plant to another in order to increase browse value for wildlife.

There is evidence to indicate that it would be possible to remove chamise,

undesirable *Ceanothus* species, manzanita, and yerba santa and encourage mountain mahogany and scrub oak. The latter two are highly desired as browse plants. It also seems possible to remove chamise and leave a stand of deer brush; but further experiment on this will be necessary.

Recommendations in this bulletin differ from those made in earlier publications because of recent findings. It must be constantly kept in mind that this is a progress report and that changes will follow when new discoveries are made and new techniques developed.

THESE CHEMICALS ARE EFFECTIVE . . .

2,4-D, 2,4,5-T, Ammate, Amino triazole, others

Formulations of 2,4-D or 2,4,5-T and mixtures of the two called "brush killers" are most widely used for controlling woody plants. The recommended brush killers contain one third to one half 2,4,5-T and two thirds to one half 2,4-D. 2,4-D is much cheaper than 2,4,5-T, to which it is related. 2,4,5-T is particularly useful for increased penetration when oil is used in the spray mixture. On mixed stands of brush it is usually preferable to use the brush killer; but if only a single brush species is to be treated it is best to determine which chemical is the more effective, since certain species are more susceptible to one than to the other.

1. Ester formulations are now most commonly used for brush control. They are not soluble in water but are generally used as emulsions. It is essential that there be agitation in the tank to keep the spray emulsion uniform. Some ester formulations on the market contain high concentrations of emulsifiers, which aid in keeping the emulsions uniform and probably increase effectiveness. Most of them are soluble in oil, but even here occasional

mixing is necessary to prevent some settling-out, or stratification, particularly of the low-volatile ether esters.

Low-volatile ether esters have generally been more effective than the high-volatile types. Those most studied and found satisfactory have been the propylene glycol butyl ether esters and the butoxy ethanol esters. Other types appearing on the market, such as the butoxy ethoxy propyl esters and iso-octyl ester, will probably be satisfactory.

2. Amine formulations are commonly used for control of weeds in cereal crops. Their most effective use on woody plants is with the addition of some nontoxic, light, emulsifiable spray oil in the 2,4-D-water mixture. For aircraft applications, we recommend 1 gallon of the oil per acre. Where individual plants are to be sprayed by ground rig, use 0.5 to 1 per cent spray oil in the mixture.

Amine formulations are generally most satisfactory when plants are growing rapidly and soil moisture is high. Under these conditions they sometimes give results superior to those obtained with esters. The amine formulations on the market are water-soluble and have little if any volatility hazard.

The amines are the most effective of the various formulations for killing trees by the cut-surface method.

3. Acid formulations emulsifiable in water are on the market. Where drift and volatility are hazards, they may be the best choice.

A new class of compounds including 2,4-D propionic acid and 2,4,5-T propionic acid are showing considerable promise on live oak and blue oak. These are similar to 2,4-D and 2,4,5-T and are used in the same way. Probably a mixture of the brush-killer type made up of 2,4-D propionic and 2,4,5-T propionic will be most satisfactory.

Ammate (ammonium sulfamate) has been used for brush control for years. Do not confuse this chemical with the

amine of 2,4-D and 2,4,5-T. The spray mixtures generally consist of $\frac{3}{4}$ pound of the chemical plus about $\frac{1}{3}$ teaspoonful of emulsifier per gallon of water. Thorough coverage is essential—which means that as much as 450 gallons of spray may be required per acre of dense brush. This chemical is effective over a wide range of growth conditions, although retreatment is usually necessary. Spray solutions of Ammate are not volatile and can be used in relative safety near growing crops and ornamentals.

Amino triazole is a new chemical that is effective on poison oak, used at rates of 2 to 4 pounds per acre in enough water to provide good coverage. This compound can be used in some places where 2,4-D or 2,4,5-T cannot be used because of hazard to surrounding plants.

Other chemicals are being developed and tested for brush control. Further work may prove these effective. Recommendations for their use will be made when we have enough information on them. Some soil-sterilant chemicals have limited usefulness for controlling woody plants.

EXTEND YOUR CHEMICALS WITH . . .

Water, oils, wetting agents, and emulsifiers

Water is generally used as the main diluting agent for foliage sprays.

Oils may be used alone or in emulsion in the spray mixture. Diesel oil and kerosene are most common. For basal sprays oil is used alone as the carrier of 2,4-D and 2,4,5-T esters. For foliage sprays it is commonly added in small amounts to increase penetration of leaves, bud scales, and bark.

Too much oil on leaves (more than 1 per cent or more than 1 gallon per acre, as a general rule) appears to increase the amount of burn and to hinder the movement of the chemical. Where very

PRECAUTIONS are necessary in the use of chemicals for woody-plant control. Both 2,4-D and 2,4,5-T are growth-regulatory-type weed killers, and may injure nearby broad-leaved ornamentals or crops.

Do not use the same equipment for applying insecticides, etc., since it is very difficult to remove all traces of 2,4-D and 2,4,5-T from the sprayers, and sensitive vegetation may thus be injured.

Ammate is quite corrosive, and the equipment should be thoroughly cleaned after using.

few photosynthetically active leaves are present—as in the case of deciduous plants in the winter—the use of considerable oil in the spray mixture, or even straight oil, is the best practice. Even so, the results are usually much inferior to those obtained with the proper application of foliage sprays when the plants are quite active photosynthetically.

Nontoxic spray oils may sometimes be used in place of Diesel oil, especially when it is thought that the small amount of burn by the Diesel oil might interfere with the action of the chemicals. Such spray oils are used in oil-emulsions for spraying trees in summer to control scale. Select an oil of light or possibly light-medium viscosity.

Where oils are to be added to the ester formulations, it is important to mix the oil with the ester before adding water.

Wetting agents and emulsifiers may be added to increase the effectiveness of the sprays. In general, the ester formulations have enough of the emulsifier in them. However, if a poor emulsion is obtained, it would be helpful to add about 4 ounces of an emulsifier or household detergent per gallon of commercial ester formulation. Aqueous solutions of

Ammate require these additives for best results. With the amine formulations of 2,4-D and 2,4,5-T, the extra emulsifiers incorporated in the spray oils that are added are usually enough. Add no more emulsifier than is necessary to insure emulsification. For high-gallonage spraying, this may range from 4 to 8 ounces per 100 gallons of spray mixture.

The best type of emulsifier to be added cannot be clearly defined (nonionic type is suggested), except that it should result in proper emulsification of the materials and that it should be relatively nontoxic to leaves at the concentrations used.

APPLY THE CHEMICALS . . .

On foliage; while dormant; as basal sprays; by cut-surface treatment; by stump treatment; or as soil applications

Application on foliage

The proper season or stage of growth for spraying woody plants is very important. Soil moisture must be adequate for appreciable shoot or root growth, if good kills are to be obtained. Since soil-moisture conditions are not entirely predictable, a considerable amount of personal judgment must be involved. Such factors as rainfall, slope, soil depth, abundance of vegetation on the site, root-shoot ratio (old plants versus sprouts following cutting or burning), root distribution, and soil fertility all influence the availability of water within a plant.

With ground equipment spray applications may be (1) made broadcast, employing a boom for completely spraying the entire area uniformly, or (2) made to individual plants or areas.

1) When using a boom, the volume of spray per acre depends on a number of factors. On some species, such as coyote brush and big sagebrush, good results may be obtained using as little as 10 gal-

lons of spray per acre, while on sprouting chamise 40 gallons per acre would be better, and on willow and poison oak possibly 100 gallons.

General recommendation: Use 2 pounds of a brush-killer mixture in 1 gallon of Diesel fuel and enough water to make 40 gallons per acre. The 2 pounds per acre represent the minimum rate of chemical to be used.

(2) When spraying individual plants, the most important thing is to place some spray on every part, including the stems. Complete coverage is more readily assured by spraying to run-off, especially the base of the plant.

General recommendation: Use 4 pounds of a brush-killer mixture (low-volatile esters) in either 1 gallon of Diesel oil or light medium summer oil and 98 gallons of water.

By aircraft. Areas covered with woody plants are often hard to get over with ground equipment, especially when a spray boom is to be used; but most areas can be treated by airplanes and helicopters, using 10 gallons of spray per acre. At present aircraft applications are limited to certain types of coastal brush and to big sagebrush.

General recommendation: Use 2 to 4 pounds of a brush-killer mixture (low-volatile esters) in either 1 gallon of Diesel oil or light medium summer oil and water to make 10 gallons per acre.

Dormant spraying

This is usually done during the winter, and is chiefly confined to deciduous woody plants, such as willows. Complete coverage of the stems is accomplished by using a power sprayer and a mixture with oil as the diluent. This method might be used where brush is dense and where it would not be advisable to spray at other times because of sensitive crop plants.

Recommendation for deciduous plants: Use 8 pounds of a brush-killer mixture (low-volatile esters) in 98 gallons of Diesel oil. Try to cover all sides of the stems, especially the base.

Recommendation for nondeciduous plants (evergreen): Use 4 pounds of a brush-killer mixture (low-volatile esters) in either 1 gallon of Diesel oil or light medium summer oil and 98 gallons of water.

Basal sprays

In this method the chemicals are used in concentrated form on the lower parts of the stems of woody plants. Best results are obtained on soils that are neither excessively wet or dry. Winter and spring applications are generally satisfactory in the chaparral and oak-woodland areas. Satisfactory kills have been obtained in the forested areas with applications made in the late spring and summer.

General recommendation: Brush-killer mixtures may not be quite so effective as 2,4,5-T alone for basal sprays, but may be preferable on the basis of cost. Use 1 pound of 2,4,5-T (low-volatile ester), which is 1 quart of most commercial formulations, in 6 gallons of Diesel oil.

Cover all sides of the stems near the ground line, using a solid-cone spray, and apply enough to have runoff at the base into the soil. Apply 2 to 3 fluid ounces of the spray mixture for each inch of stem diameter. This method is most useful on stems up to 2 inches in diameter. Stems larger than 2 inches should be frilled or cut into near the base and the spray mixture applied liberally to the cuts.

Cut-surface treatment

This is used for elimination of trees. You will need (1) a hatchet or axe; (2) a pump oil can; and (3) 2,4-D amine, the undiluted formulation. Make

cuts with the axe or hatchet through the bark and well into the wood, spacing the cuts about 6 inches apart (center to center of each cut).

On species that are hard to kill, such as live oak, make the cuts continuous in a line around the tree near the ground. It is important that the cuts be completely filled with the liquid. Trees can be killed any time of year by this method, but late-fall, winter, and spring applications appear to be the best. Trees are hardest to kill when soil moisture is low.

Stump treatments

Use the same solution as for the basal-spray method. Apply it to the top of the stumps, as well as to all of the sides to the ground line, with run-off into the soil. Use about 1 pint for every 6 inches of stem diameter. This quantity will generally prevent sprouts from developing; the use of smaller dosages reduces sprouting and of course is cheaper.

The cut-surface method may also be used in treating stumps. Fill the cuts with the amine of 2,4-D from a pump oil can. About 2 milliliters ($\frac{1}{2}$ to 1 teaspoonful) are required to fill a cut. There may be some merit in using formulations containing more than 4 pounds of 2,4-D per gallon.

Another method, which may be cheaper, is painting (daubing) freshly cut stumps—to the point of run-off—with the straight formulation of the 2,4-D amine. Cover the cut bark and about 4 inches of the sapwood. It is not necessary to cover the heartwood on large trees. As with the cut-surface method, this treatment is most effective from November through May. Sprouting will be almost eliminated on such species as blue oak; on vigorously sprouting species, such as interior live-oak, sprouting will be eliminated on many stumps and reduced on the others. This will make the treatment of sprouts easier by the use of foliage sprays.

Soil applications

Soil sterilants can be used for elimination of woody plants, but cost and resulting bare soil limit the usefulness of this method (see circular 446).

YOU WILL NEED SOME EQUIPMENT . . .

**Knapsack or hand sprayer;
power sprayer; mist blowers;
aircraft**

Knapsack and hand sprayers

Four-gallon knapsack sprayers equipped with a double-action trombone pump have been used for controlling wild currants and gooseberries (ribes), which are alternate hosts for the white pine blister rust. The sprayers should be equipped with oil-resistant hose and washers. Knapsack sprayers and compressed-air sprayers of various types are on the market. Proper nozzles and tips, shut-off valves, oil-resistant hose, and washers all help to make application easier and better. *It is wise to have a supply of the parts that may need re-*

placement and to wash the sprayers after each use.

These sprayers are useful for fire-fighting, but should not be used for spraying other vegetation since the complete removal of 2,4-D is difficult, and sensitive plants might be damaged.

Power sprayers

Large areas of brush are systematically sprayed using truck-mounted sprayers. In some cases the trucks are stationary while the sprays are being applied. Long main lines of hose may lead away from the truck, and at specified distances side hoses may be attached to these. You may need pressures of 60 to 600 pounds per square inch. Areas as far away from the pumper as 3,000 feet are sprayed in ribes control. Pneumatic-type quick couplings are used, and the hose can be easily extended or contracted at will.

Spray booms attached to the truck or sprayer may be used for roadside spraying. Mechanical agitation in the spray tanks insures a uniform mixture of the spray solution. When it is not pos-

Below: Tractor sprayer making chemical applications to mountain misery (or bear clover). (H. R. Offord) Right: Knapsack sprayer has a 3-nozzle boom for uniform broadcast application of spray. The boom can be quickly exchanged for a single nozzle.





Light-weight portable spray rig that can be carried by two men to remote places. Water can be pumped from streams with the gasoline-driven pump. Hose of varying lengths can be extended from the tank.

sible, agitation can be accomplished by a vigorous return flow of at least 10 per cent of the spray mixture from the pump.

Small, light-weight power sprayers can be built, adaptable for use away from roads. The unit shown here can be easily carried by two men. Fill the fabric tank from a nearby stream, using the same pump that dispenses the spray solution.

Use booms with power sprayers to spray areas uniformly. Equipment is still not available for spraying many types of brushy sites.

Mist blowers

These are used in orchards to apply insecticides to trees. The same type of blower has been used for roadside work

and for control of big sagebrush. Although mist blowers have many limitations, they can be used for some brush spraying. *Avoid drift onto sensitive crops.*

Aircraft

Helicopters and airplanes are used to spray limited acreages of brush in California. Most spraying has been done using 10 gallons of total spray solution per acre. Wherever possible, flights should be flagged. Best results are obtained when the width of each flight path is not over 35 feet. Helicopters have been used mainly for spraying coastal brush, and airplanes for spraying big sagebrush. To insure better or more uniform coverage, areas are sometimes flown twice.

THE PHOTO ON PAGE 3 shows an operator using a knapsack sprayer with a double-action trombone pump. Bureau of Entomology and Plant Quarantine, USDA; photo by H. R. Offord.

A detailed discussion...

**of woody-plant control as it relates to
rangeland species; forest species;
drainage areas; roads and trails;
rights of way; poison oak; water
conservation; and wildlife**

RANGELAND SPECIES . . .

**Coyote brush; coast sage-
brush; purple and white sage;
mixed coastal brush; chamise;
chaparral; oak woodlands;
big sagebrush**

Coyote brush. Encroachment of coyote brush onto pasture land can well be handled by the use of chemicals. This was demonstrated by the late J. T. McNamara, Farm Advisor of San Mateo County. From a series of tests, in 1945 and later, he found that 2 to 3 pounds per acre of actual 2,4-D (acid) as the amine salt would kill coyote brush. Application by helicopter in May or June, with the amine of 2,4-D in 10 gallons of

water per acre, has become standard practice.

Results of recent tests have shown that coyote brush could be killed as late as September 1 by adding 1 gallon of light emulsive summer-spray oil to the mixture containing 3 pounds of 2,4-D (amine form) and 8 $\frac{1}{4}$ gallons of water per acre. In tests by Bryan Sandlin, Farm Advisor in San Mateo County, and others, this combination has given excellent control in June. Although oil is not necessary at this time, it is advisable where growth conditions are not optimum. Some poor results in 1951 may be attributed in part to the fact that no oil was added to the spray mixture.

Left: Coyote brush killed by the use of 2 pounds of brush killer per acre, applied by helicopter in 1 gallon of Diesel oil and 8 $\frac{1}{2}$ gallons of water. Note the abundance of grass in the formerly dense brush area. (George Wheelwright ranch in Marin County.) Right: California coast sagebrush controlled (almost 100 per cent) by 2,4-D, applied at the rate of 2 pounds per acre (amine salt) in 6 gallons of water. Note the abundance of grass. On the right the sprayed area was disked several months after spraying. (Sedgewick ranch near Los Olivos, Calif.)



Results have been good with the low-volatile esters of 2,4-D applied from June to September, at the rate of 2 pounds per acre in 9½ gallons of water—or in 1 gallon of light emulsive-spray oil and 8½ gallons of water.

Because of the wind and fog common in the coastal area, the cost of flying is high; and only a limited acreage can be treated by this method each season.

The use of ground equipment is necessary to increase the acreage now being treated. This will make more clearing possible and is well suited to the treatment of scattered plants, where broadcast sprays are not needed. With ground equipment the farmers themselves become familiar with the brush-killing chemicals and learn how to use them.

Spraying with chemicals is superior to clearing by bulldozer or tillage because it does not denude the soil. Native perennial grasses are released from competition with the coyote brush and grow abundantly.

Coast sagebrush, purple sage, and white sage. These plants sprout after a fire; this is one reason for the use of chemicals in their control. Coast sagebrush and the sages are sensitive to 2,4-D, and the same recommendations are made for them as for coyote brush. Give careful attention to soil-moisture conditions, since they grow in areas where rainfall is erratic and soil moisture may be low. Most spraying has been done in March and April in Ventura and Santa Barbara counties, and in May or early June farther north.

Mixed coastal brush. Mixed stands of brush are more common than comparatively pure stands of coast sagebrush or coyote brush. Some are almost impenetrable. Their botanical composition varies considerably, depending upon slope, soil, exposure, rainfall, temperature, and grazing history—and may include coyote brush, coast sagebrush, blackberries, poison oak, blue blossom

or California lilac, thimbleberry, hazelnut, etc.

General recommendation for aircraft spraying.

Use 3 pounds of a (brush-killer) mixture in 1 gallon of light-medium spray oil and 8¼ gallons of water per acre.

The sprays have a striking effect on most mixed coastal brush, especially during the same year the plants are sprayed. But unless some additional treatments are made to convert the areas from brush to grass, many of the woody plants will recover. Unlike the sites occupied by California coast sagebrush and coyote brush, these areas may almost completely lack resident grasses, and seeding will be necessary. Such areas are well suited to the use of truck-mounted spray rigs, which can be driven along roads and hill crests. By the use of several hundred feet of hose from such rigs, much of the mixed brush in coastal areas could be retreated the year following the helicopter application. Other methods of retreatment may also be used.

One seeding method used successfully by George Wheelwright in Marin County is to feed grass hay to cattle in different parts of the dense brush areas that have been sprayed by helicopter. He is careful to use desirable grass and clover seeds in the hay, and to keep out troublesome weed seeds. The cattle eat the hay, tramp seed into the soil, and eat some of the brush. If this is followed by some respraying, it appears remarkably successful in converting areas from dense brush to good grass.

General recommendation for ground spraying.

Use 4 pounds of a brush-killer mixture with 1 gallon of either Diesel oil or light medium oil and 98 gallons of water.

It is often hard to burn brush in the coastal areas unless it has first been

sprayed. Burn in late summer and seed it once. Scatter weed-free hay over the area, and let in cattle or sheep. The tramping of the livestock should help cover the seed, thus insuring a good stand of grass. Get the desirable plants off to a good start, so that they can compete with the weeds and sprouting brush; this means these areas cannot be grazed until the grass is well established. The sprouting brush and the numerous weeds will soon crowd out the planted grass unless some respraying is done. It is much easier to spray by hand or power sprayers where a good burn has occurred. Whether burning these areas is desirable varies with the site. In some cases brush removal without fire may be the most desirable. Use of chemicals will help make this possible.

Chamise. This plant generally occurs on the poorer soils, which may be steep and rocky. Control by chemicals may not be practical or desirable; but where control is wanted, chemicals can be helpful.

Old chamise has been hard to kill by aircraft application. The values to rangeland of merely killing old chamise by chemicals are not great, since native annual grasses invade such areas slowly and no successful plantings of either grasses or legumes have been made without seed coverage. However, it is possible to spray the chamise, then crush it with a bulldozer, and seed the area. Some follow-up spraying will be necessary to finish killing the chamise surviving the aircraft application.

Sprouting chamise and chamise seedlings can be controlled by aircraft application. This has been shown in cooperative tests with W. C. Lusk, Farm Advisor for Lake County, and C. E. Carlson, of the State Division of Forestry. Well over 100 aircraft tests had previously been made without success. One method that has now been suc-

cessful in four tests is to follow a summer or fall burn with a spraying in the following April or May. Best kills by aircraft spraying will be obtained if most of the sprouts are not over six inches tall. Sprouts must be present in order that the spray kill the plants.

The approximate cost of spraying will be about \$6 an acre.

Two pounds of 2,4-D (low-volatile ester) in 1 gallon of Diesel fuel and water to make 10 gallons per acre have been used. This treatment has resulted in nearly 100 per cent kill of the chamise seedlings and an 80 per cent or greater kill of the chamise sprouts. Spraying tests indicate that a higher rate of 2,4-D may increase the kill even more.

The aircraft method used on the area shown here may be effective. The chamise was burned almost two years before the sprouts were sprayed with 4 pounds of a brush-killer mixture (low-volatile esters) applied in 4 gallons of a non-toxic oil per acre. The 2,4,5-T is necessary when applications are made using straight oils and appears more readily absorbed through bark. Cost of the spray materials would limit the use of this treatment to cases where other difficult species are present.

Satisfactory ground applications have been made using 2 pounds of 2,4-D (low-volatile ester) applied in 2 gallons of Diesel fuel and water to make 40 gallons total spray per acre; twice as much 2,4-D has been appreciably better. Excellent kills have resulted from November through May on one- and two-year-old chamise sprouts, while the results on older sprouts have been less consistent. Unfavorable soil-moisture conditions are usually the main reason for poor kills.

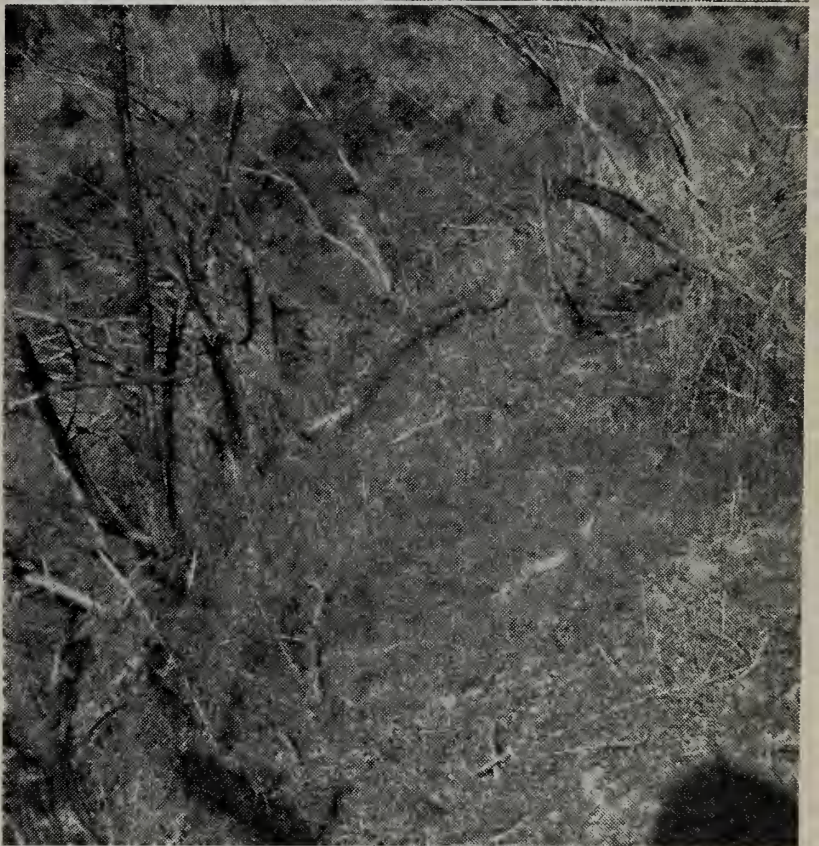
However, a burn in August of the same year in which the chamise is sprayed may result in a very high degree of kill of the chamise sprouts. For example, a 94 per cent kill of three-year-

old chamise sprouts was obtained following an August burn on an area treated with 2 pounds of 2,4-D per acre; the kill of chamise sprouts on the unburned sprayed area was only 33 per cent. In this case, the spraying made the burn possible, since the fire largely restricted itself to the sprayed area. The burning must be done the same year as the spraying to be effective in improving the kill of chamise sprouts.

The spray mixture described above (2 pounds 2,4-D in 2 gallons Diesel fuel and water to make 40 gallons spray per acre) may be very useful in converting a chamise cover to perennial grass (See Table 1, page 17). The chamise and other brush was crushed with a bulldozer in the summer of 1950, burned early in October, and seeded at once by airplane to hardinggrass, smilo, tall fescue, rose clover, and a few minor species. An excellent stand developed. The following factors added to the success of the seeding. (1) The brush was crushed the same year and before the burning took place, so that weedy grasses had not developed. (2) Crushing made a thorough burn possible. (3) Seeding occurred immediately after the burn and shortly before rains were expected. This allowed the seed to be partly covered by the ash and protected from birds. Crushing made the area accessible so that it could be sprayed with a boom.

Sprays applied in the spring of 1951 and 1952 were highly effective in killing not only chamise sprouts but also yerba

Top: Smilo established on a chamise-covered area by spraying, crushing the brush, and seeding. (George Allen ranch, Sutter Creek, Calif.) Center: Two-year-old chamise sprouts killed by spraying with helicopter. The area appears to have been satisfactorily converted from brush to grass. (L. J. and George Gamble ranch, Knoxville, Calif.) Bottom: Chamise burned and seeded to perennial grasses. Plot in background sprayed the second year after burning; area in foreground not treated. (Hollister and Warren ranch, Rescue, Calif.)





santa, golden fleece, deer-weed, rush rose, creeping sage, and brush seedlings (including chamise, *Ceanothus*, manzanita, etc.). An appreciable percentage of the toyon was killed by the spray. Interior live oak, coffeeberry, and redbud were not killed and would have to be treated by individual plant treatments (See Table A, p. 28).

For successful aircraft application, spraying the first year after a burn may be necessary. By ground application satisfactory kills may be obtained the second year. This has advantages: (1) it allows time for the planted clovers to go to seed once and thus build up a reservoir of hard seed in the soil; (2) it gives more time for the germination of brush seedlings; and (3) it allows the perennial grasses to become better established so that they are less injured by the sprays.

Encouraging the natural establishment of grass by spraying has an important bearing on soil erosion. Spraying will benefit grass seedlings, whether these are made with annuals or perennials. Where fire and erosion are problems, sprays may be very important in converting chamise cover to a grass cover. Chamise may also be controlled along roads and rights of way, by methods described in Tables A, B, and D, pp. 28-36.

Top: The brush in this area was knocked down with a bulldozer and burned. Area has not been seeded or sprayed. Note the abundance of sprouting brush and brush seedlings, as well as the absence of grass. (Hollister and Warren ranch.) Center: Chamise area completely converted from brush to grass, with very little erosion following a reburn. The area was burned, sprayed, and reburned. Note the dense stand of resident annual grasses. (L. J. and George Gamble ranch, Knoxville, Calif.) Bottom: Chamise area following a reburn and subject to considerable soil erosion. Most of the chamise plants have once again developed sprouts from the burls at the base. This area should have been seeded following the initial burn. (Gamble ranch.)

Table 1. The effect of spraying at different times of year on the kill of brush sprouts and seedlings. The chamise was burned in 1950, seeded to perennial grasses, and sprayed in 1952 with 2 pounds of 2,4-D (low-volatile ester) in 2 gallons Diesel oil and 38½ gallons of water per acre. Notes on the kill of woody plants were recorded in the summer of 1953.

Date of treatment	Number of live plants per acre					
	Chamise sprouts	Toyon	Yerba santa	Brush seedlings		
				Chamise	Ceanothus	Manzanita
Feb. 25	150	0	0	0	0	0
March 28	180	0	0	0	0	0
April 17	0	0	0	0	0	0
May 16	330	43	20	172	21	0
July 14	1,435	43	21	2,150	258	43
Untreated	1,500	43	344	3,784	2,150	129

Chaparral. The term chaparral as used in California refers to shrubby vegetation with predominantly broad and thick evergreen leaves—including the various manzanitas, Ceanothus species, and scrub oak.

Chaparral would be handled in a manner similar to chamise (above), especially after burning. Although not at present recommended, one test using a helicopter appears to have been successful on a scrub oak area. Using high-



Scrub oak killed by spraying with helicopter. Browsing by deer after spraying contributed to the kill. The area was burned 1½ years before spraying, and is virtually freed of chamise and other brush. Broadleaf weeds are not abundant. (L. J. and George Gamble ranch.)

volume applications with a ground rig, successful control of all chaparral species is assured, but retreatment will be necessary.

Although both manzanita and Ceanothus species are sensitive to 2,4-D and 2,4,5-T and can be killed by either chemical, manzanita responds better to 2,4-D and Ceanothus to 2,4,5-T. Stands of mature wedge-leaf Ceanothus have been killed by 2 pounds of 2,4,5-T in 4½ gallons of Diesel oil per acre, applied by helicopter. Since chaparral generally consists of a mixture of shrubby species, it would seem desirable to spray them with a brush-killer mixture.

Oak woodlands. The blue oak (sometimes called white oak) is the easiest California oak to kill with chemicals. Use 2,4-D amine and the cut-surface method, which is selective in that individual trees can be killed or an area thinned out. Table 2 (p. 18) presents data on the cut-surface method at different times of year and indicates that November through June is the best period. Good control can be had at all times of year if the cuts are placed close together, near the base of the trunk, deep enough to reach well into the



A blue oak tree treated with the amine of 2,4-D in hatchet cuts. (John Allen ranch, Sutter Creek, Calif.)

Table 2. The effect of season of application of 2,4-D amine, 2 ml (½ tea-spoon) per cut, on kill of blue oak trees.*

Date of application	Top kill	Sprouting
	per cent	per cent
August, 1951	70	0
October, 1951	90	20
November, 1951	100	0
December, 1951	100	0
February, 1952	100	0
March, 1952	100	0
April, 1952	100	0
June, 1952	100	0
July, 1952	90	0

* The cuts were approximately 6 inches apart (center to center of the cuts) and 12 to 24 inches above the ground.

wood—and if enough chemical is applied.

Aircraft spraying of blue oak trees has not so far resulted in a high degree of kill. The best kill (25 per cent) was in a test using 2 pounds of 2,4,5-T ester in 4½ gallons of a summer-spray oil having a viscosity of 6l.

Blue oak sprouts are often a problem after land clearing. George Greilich, of Plymouth, California, removed 150 acres of blue oaks by bulldozing in 1950 and spraying the sprouts in July, 1951. He used 1,200 gallons of solution containing 4 pounds of 2,4,5-T (low-volatile ester) in 99 gallons of water. There were about 40 to 50 sprouts per acre. Four hundred gallons of spray were needed for retreatment in 1952. This virtually freed the entire area of blue oak sprouts. Basal sprays are effective on trees as well as on sprouts, if enough spray is used.

Digger or bull pine, common in oak woodlands, is objectionable to ranchers, because the grass beneath the trees is not readily eaten. The cut-surface method of chemically killing digger pines has certain advantages: it is cheap, and the trees decay rapidly after treatment. A tree will

Table 3. Kill of digger pine on the L. J. and George Gamble ranch in Napa County using the cut-surface method of treatment.

Chemical used	Spacing of the cuts	Quantity chemical used per cut*	Kill
		milliliter	per cent
2,4-D amine.....	6 inches apart	1	90
2,4-D amine.....	6 inches apart	2	100
2,4-D amine.....	6 inches apart	4	100
2,4-D amine.....	12 inches apart	1	100
2,4-D amine.....	12 inches apart	2	100
2,4-D amine.....	12 inches apart	4	100
2,4,5-T amine.....	6 inches apart	1	20
2,4,5-T amine.....	12 inches apart	1	0

* One teaspoon holds 4 milliliters.

fall down within 3 or 4 years, after which the entire tree can be burned. If a digger pine is cut with a saw, the dead stump will remain in the way for many years.

Axe cuts should be spaced about every 8 inches around the tree and deep enough to be well into the wood. The 2,4-D amine (undiluted formulation) appears to be the best chemical, and the winter and spring months result in the most rapid kill. Each cut should receive about 1 teaspoon of the 2,4-D amine. Table 3 presents results of one experiment on the cut-surface treatment of digger pine.

The 2,4-D amine was highly effective

on digger pine, as can be seen from the table, while 2,4,5-T amine was much less effective. Digger pine has been treated at all times of year and appears to be sensitive at all seasons. Poor results are apt to be obtained from summer application if the work is not carefully done.

Interior live oak is the most important of the oak-woodland species and hardest to control. Live oak trees can be killed using the cut-surface method. Table 4 presents typical data on the cut-surface method on live oak. A frill is superior to spacing the cuts 6 inches apart. Rather closely spaced cuts (every 4 inches) were

Table 4. The kill of live oak with 2,4-D amine applied to a frill and to discontinuous cuts.*

Date of application	Per cent kill	
	Frill	Cuts 6 inches apart (center to center of the cuts)
	per cent	per cent
December, 1951.....	100	80
July, 1952.....	70	20
December, 1952.....	100	100
March, 1953.....	100	60

* The rate of application was one milliliter (one-fourth teaspoonful) per inch of stem diameter.

effective when enough 2,4-D amine was used.

The cut-surface method has been effective on live oak stumps. Sprouts have been either eliminated or greatly reduced by the 2,4-D amine applied to a frill around the stump. Soaking the top of the freshly cut stump with the 2,4-D amine also markedly reduces sprouting and may be preferable, since the cost of application would be much less. This will not be effective unless you apply all of the chemical that will stick on top of the cut stump.

Stump spraying is also useful on freshly cut live oak and will largely prevent sprouting if enough spray is used and if the application is properly made. Smaller quantities of spray will reduce sprouting and may be more economical. Ivan Lehman of Latrobe, California, sprays the stumps with a brush killer mixture in Diesel oil (about 4 pounds of each chemical to 24 gallons of Diesel). The sprouts are controlled with the same mixture, when they are still quite small—6 to 10 inches. He has found that two to three times over the area virtually eliminates live sprouts.

In general, basal sprays are better suited for use on the smaller stems of

live oak, such as develop after burning or cutting. In tests conducted on 2-year-old sprouts, about 1 pint of 2 per cent 2,4,5-T per clump resulted in killing most of the clumps.

On the larger stems it is best to chop cuts in several places near the base and fill them with spray. When this method is used, some retreatment will be needed.

Foliage sprays are of greater general use for live oak than other methods. A single foliage spray may result in a high degree of kill of live oak sprouts; but some of the sprouts may have to be sprayed as many as 3 or 4 times before they are completely killed. Very thorough coverage of all leaves and stems to the ground is important. One good application may do a better job than three poorly made applications. May through July are often best for spraying, although sprays are effective as long as there is an abundance of healthy leaves. October through December appears to be an effective period.

General recommendation: Use 4 pounds of acid equivalent of a brush-killer mixture of 2,4-D and 2,4,5-T, plus 1 gallon of Diesel oil, and water to make 100 gallons of spray mixture. Sprouts are best sprayed when they are not over

Left: The 2,4-D amine frill treatment on interior live oak. (Hollister and Warren ranch, Rescue, Calif.) Right: Area on which live oak has been completely controlled by spraying the sprouts. (Ivan Lehman ranch, Latrobe, Calif.)



one year old; an increased quantity of spray is needed on older bushes.

Good results have been obtained with the amine of 2,4-D on live oak sprouts sprayed in October. The best mixture consisted of 4 pounds of 2,4-D (amine) in $\frac{1}{2}$ gallon of a light-medium emulsifiable summer oil and 100 gallons of water. To succeed, this method needs: (1) thorough coverage of both the upper and lower surfaces of the leaves, buds, and stems to the ground; (2) an abundance of healthy leaves; (3) the addition of a little nontoxic emulsifiable spray oil to aid in penetration; and (4) fall application, since live oak becomes more sensitive to 2,4-D during this period (as shown by the cut-surface treatment). Recent trials indicate that the best kill of live oak sprouts will be obtained with either a mixture of 2,4,5-T propionic and 2,4-D propionic or 2,4,5-T propionic alone (see page 30).

Ranchers are doing considerable spray work on live oak sprouts using a brush-killer mixture applied in water, or using 1 per cent Diesel oil. Within 3 or 4 years a number of fields have been virtually freed of live oak.

Mixed brush species also occur in the oak woodlands, including coffeeberry and redberry. They can be controlled by the same mixtures as used on live oak, but two or three applications may be necessary. Other brush species may also be present and can usually be controlled with the same brush-killer spray. Spray from April through July, depending on soil moisture and species. Consult recommendations for specific woody plants on pages 30, 35, 36.

Big sagebrush. This occupies about 5 million acres of land in California and about 100 million acres in the United States. It is sensitive to 2,4-D. In recent tests 2 pounds of 2,4-D esters in $\frac{1}{2}$ gallon of Diesel oil and 9 gallons of water per acre applied by airplane in June resulted in a 94 to 98 per cent kill of

big, silver, and black sagebrush. Spraying strikingly benefits the growth of grass by reducing competition. Several thousand acres are being sprayed each year, and the number is on the increase.

The turbine blower has been successfully used in spraying big sagebrush. It is useful where yellow pine and sagebrush are mixed and on rocky or rough topography. A boom mounted on a tractor sprayer can be used on level ground.

FOREST SPECIES . . .

Wild currants and gooseberries; mountain misery (bear clover); manzanita; Scotch broom; weed trees

Wild currants and gooseberries.

Chemical studies on ribes control have been conducted since the 1920s. In the west about 25 species are found in sufficient numbers to be important to the blister-rust control program. Specific control measures have been developed for each species. Where an admixture occurs—some sensitive to 2,4-D and others to 2,4,5-T—the latter is used.

On one such area in northern Idaho, excellent control has been achieved with one application of an aqueous spray of 2,4,5-T esters from mid-May to late August. Sticky flowering currant, swamp currant, western black currant, and white-stemmed gooseberry were the species involved. The sprays were applied with a power sprayer and hose lines of 2,500 feet or more. Bushes were completely covered with the spray—stems, crowns, and basal parts. Such treatment has resulted in nearly 100 per cent control, except after early September when the results with an aqueous spray have never been so good. However, the use of 10 per cent stove oil in the spray mixture has made late-season spraying as effective as during the normal spraying season. Complete coverage of the whole plant, including basal drenching with the spray mixture, is necessary for best control.

The Sierra gooseberry—very important in the Sierra of California—is readily killed, generally with low dosages of an aqueous spray of 2,4-D ($\frac{1}{3}$ pound per 100 gallons of water), especially in June. As the season progresses, it becomes increasingly hard to kill. Also, bushes in association with heavy stands of mixed species of brush are hard to kill by foliage sprays at all seasons.

Basal sprays on ribes are especially useful where poor results from foliage sprays are probable. In general, the esters of 2,4,5-T are preferable to the esters of 2,4-D, with very thorough wetting of the lower part of the stems and root crown essential. Mixtures of these two chemicals are satisfactory, and on some species 2,4-D esters are permissible.

Stump or decapitation methods were formerly used more than now. Control can be had with oil alone, or using a basal-spray mixture and thoroughly wetting the cut stumps and crowns.

Mountain misery, or bear clover. Woody plants are often so abundant in California forest lands that they interfere with the survival of hand-planted trees. Mountain misery, one of the commonest, can be controlled using 2,4-D or a brush-killer mixture applied from March through early June (see Table A, page 30).

Manzanita. Competition with sprouting manzanita may also lead to a very low degree of survival of planted pine seedlings. Chemical control in pine plantations would be warranted.

Scotch broom. This is a serious pest in several Sierra Nevada counties. It invades pastures, grows in dense cover along roads, infests yellow pine forests enough to hinder pine reproduction, and creates a serious fire hazard. French broom and common broom are also present in some areas.

All are readily controlled with basal brush-killer sprays in Diesel oil. For foliage spray of Scotch broom use 2,4-D esters in water containing $\frac{1}{2}$ per cent summer oil (2 pounds of 2,4-D in $\frac{1}{2}$ per cent summer oil and enough water to make 100 gallons of spray) in June and July (just past the peak of flowering). Such a spray has resulted in nearly 100 per cent kill of the plants, but seedlings have developed beneath the killed Scotch broom, and further spraying is necessary to kill these seedlings.

Weed trees. Oak, madrone, and other trees occurring in stands of commercial forest trees result in inefficient use of the land. Basal sprays and 2,4-D amine applied by the cut-surface method may be used in their control.

Left: *Ribes roezli* killed with a foliage spray using the sodium salt of 2,4-D. (H. R. Offord) Right: Crown of large *Ribes cereum* brush decapitated and treated with a 1:1 mixture of Diesel oil and furnace oil (H. R. Offord).



SPECIAL PROBLEMS . . .

Drainage areas; roads and trails; rights of way; poison oak; water conservation; wildlife

Drainage areas. Willows can be sprayed with 2,4-D after the leaves have developed in the spring, continuing through the summer and fall as long as the leaves remain healthy and the soil moisture is *high enough for growth*. It is sometimes possible to spray until about November 1, while in other cases the results may be poor after August 1. Esters of 2,4-D are preferable, but amines may be used where there is some chance of damaging a sensitive crop because of volatility or spray drift.

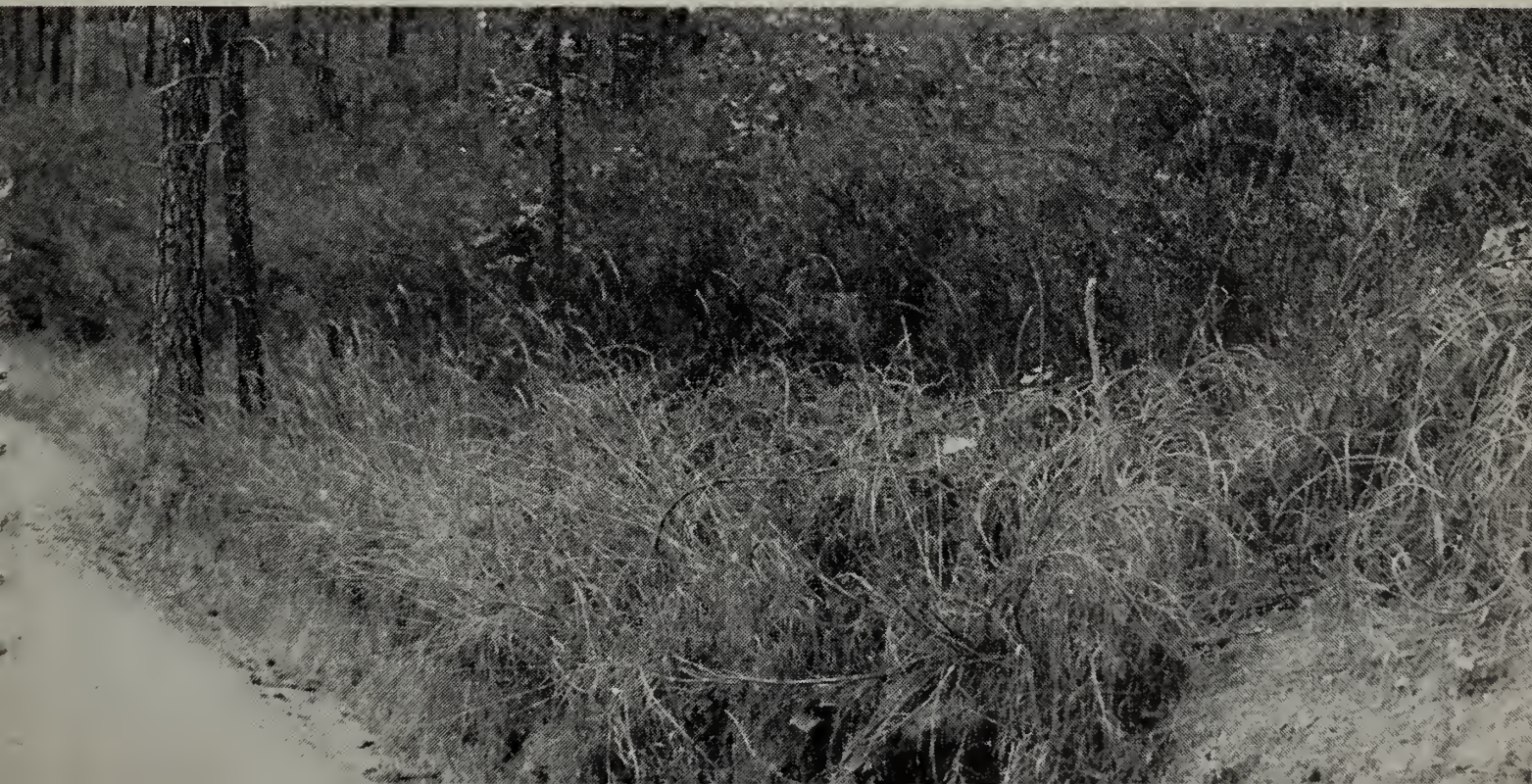
Sensitive crop plants in nearby fields may complicate the problem of control. Because of state regulations on the use of herbicides, it may be possible to spray only from October 15 to March 15. This necessitates the use of chemicals during a time when foliage sprays are of limited importance. Basal sprays and stump sprays have gained favor for use during these periods.

Where there is a mixture of woody plants growing along a drainage area, brush-killer mixtures of the esters of 2,4-D and 2,4,5-T are used (see page 8).

Roads and trails. Sprouting brush and brush seedlings along roads, trails, and firebreaks have been expensive to remove by hand-cutting or bulldozing. The rapid regrowth of many species makes it necessary to repeat the operation every few years, and the stand density tends to increase from the apparently beneficial "pruning" effect of the cutting. Recently chemicals have been used because of their comparative cheapness and because less disturbance of the soil results in less erosion. The appearance of the area is also more pleasing after the killed brush disappears.

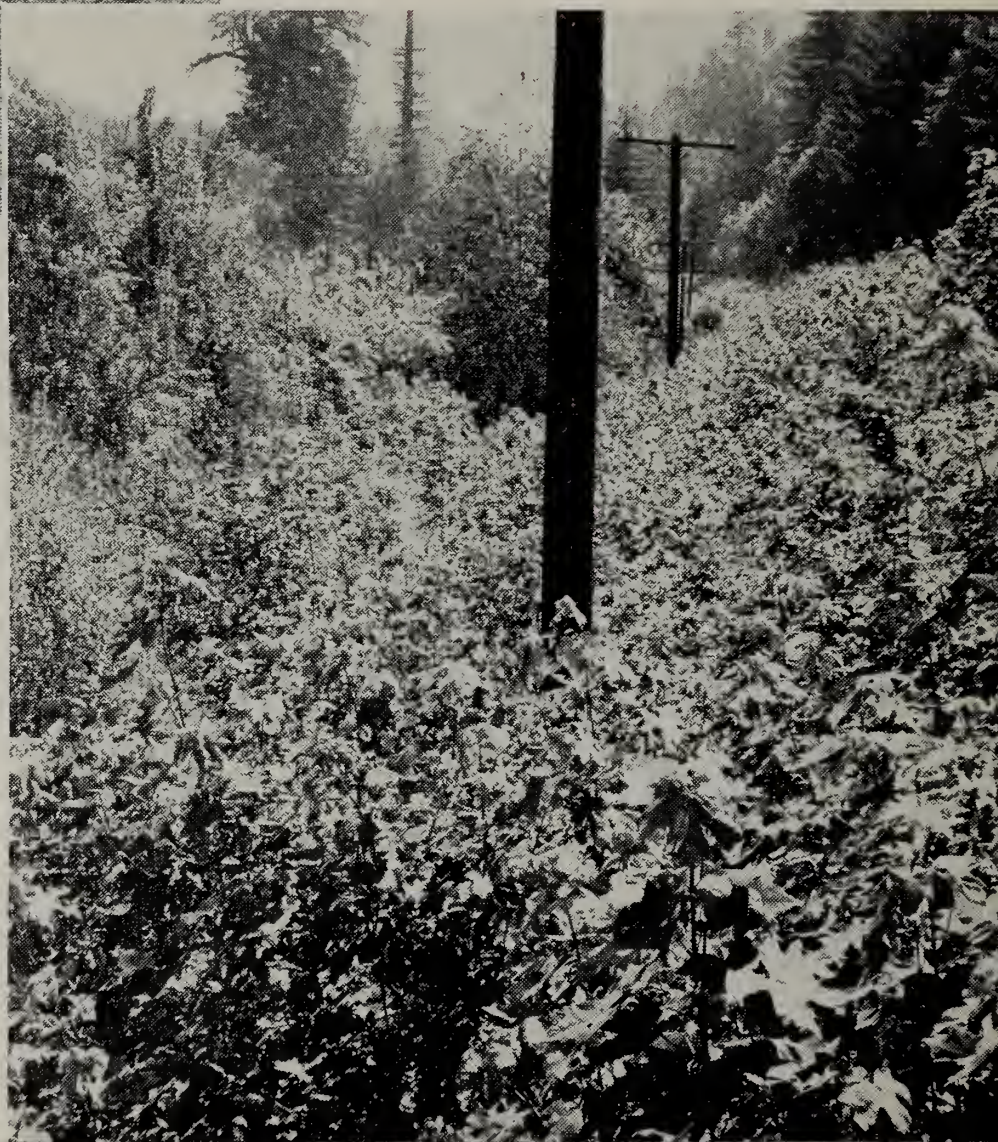
Brush along roads and trails should be cut by a brush mower or by hand. This gets the larger brush out of the way and makes possible more thorough chemical control. For the Shasta-Trinity National Forest Neuns and Simpson (see Literature Cited) recommend using $1\frac{5}{8}$ pounds of 2,4,5-T and $\frac{3}{4}$ pound of 2,4-D (low volatile esters), plus 1 to 5 gallons of Diesel oil in enough water to make 100 gallons of spray. Plants should be treated while they are growing rapidly, but not before the leaves are fully enlarged on deciduous species. In forested areas this actually means June to October and varies with elevation. *Be sure to cover all the leaves and stems completely*, since complete coverage

Scotch broom killed with 2,4-D. (Lowell Mobley, Agricultural Commissioner, Placerville, Calif.)





These pictures are all of the same area along the Pacific Telephone & Telegraph lead-line on the Northwestern Pacific Railroad at Southfork, Calif. Top: A spray train in operation; at left: After spraying (note dead maple and thimbleberry shoots); below: One year's regrowth after cutting. (Courtesy Dow Chemical Co.)



means good control. Carry a power sprayer on a truck and spray the bushes individually, using hand booms as the truck drives along the road. Excellent results have been obtained with one application of the spray, but a second spray is necessary on many bushes in succeeding years. After that the program is placed mainly on a maintenance basis.

Common plants controlled include sprouting manzanita, such as the green-leaf manzanita, snowbrush, cherry, and chinquapin. At lower elevations the Brewer oak, black oak, and interior live oak are controlled.

Some work has started along trails. In one case a mule carried four 4-gallon pressure tanks, with pressure maintained by CO₂ cartridges. The sprays are used in highly concentrated form. Low gallonage is necessary, since transportation is the major problem.

In El Dorado and Amador counties roadsides have been sprayed, using both 2,4-D and brush-killer mixtures (low-volatile esters). Results have been good with follow-up resprays. An Essick sprayer was used in El Dorado County and a Bean sprayer mounted on a 2-wheel trailer in Amador County.

A Buffalo Turbine blower has been used in Humboldt County for spraying roadsides. (In 1953 the cost was \$5.64 per mile—both sides.) Considering the cost, the results have been satisfactory. Clean-up sprays on individual plants will be used after the first one or two years.

Rights of way. Since access may be difficult, it is best to use the chemicals in concentrated form. Directly after the brush is cut, spray the stumps with 2 per cent 2,4,5-T or a brush-killer mix-

ture in Diesel oil. Spray tops and sides of stumps thoroughly; the amount of retreatment will depend on the thoroughness of this operation. Some sprouts will develop and need to be treated with the same spray for two succeeding years.

A variety of sprays may be used, depending on the availability of water and on transportation. Ammate (ammonium sulfamate) is used where there may be danger to neighboring crop plants from drift.

Poison oak. Widely distributed in California, poison oak is common in the Sierra in southern California, and along the Coast Range north to the Oregon



Above: High brush was hand-cleared and the stumps and low-growing brush immediately treated with 2,4,5-T in Diesel oil. A touch-up treatment with the same material was made the next year. (Along the Pacific Telephone & Telegraph Redding-Weaverville lead.) Below: New right of way cleared with the same solution as above, along the Pacific Telephone & Telegraph Vavarro-Albion lead. Sprouts were basally and foliage sprayed. Redwood suckers and tanbark oak were controlled. (Courtesy Dow Chemical Co.)

border. It is not related to true oaks, but to poison ivy, found in other parts of the United States.

2,4-D, 2,4,5-T, Ammate, and amino triazole are all used in its control. Brush-killer mixtures of 2,4-D and 2,4,5-T are more effective than either chemical alone.

Since brush killers may injure nearby broad-leaved ornamentals or crops, apply them with low-pressure spray—not more than 30 pounds—when there is little or no wind. For best results, use them before the leaves begin to turn yellow or red. Amino triazole is as effective as the brush-killer mixtures and may be used with greater safety to surrounding vegetation.

Although Ammate is more expensive than brush killers, it can be used when plants are older and is safer to use near ornamentals and crops. Add a wetting agent. Retreatment the following year is usually necessary, and some plants will

continue to sprout for three or four years.

Do not burn poison oak. Oils in smoke, especially if inhaled, can often be more harmful than the effects of touching the plant.

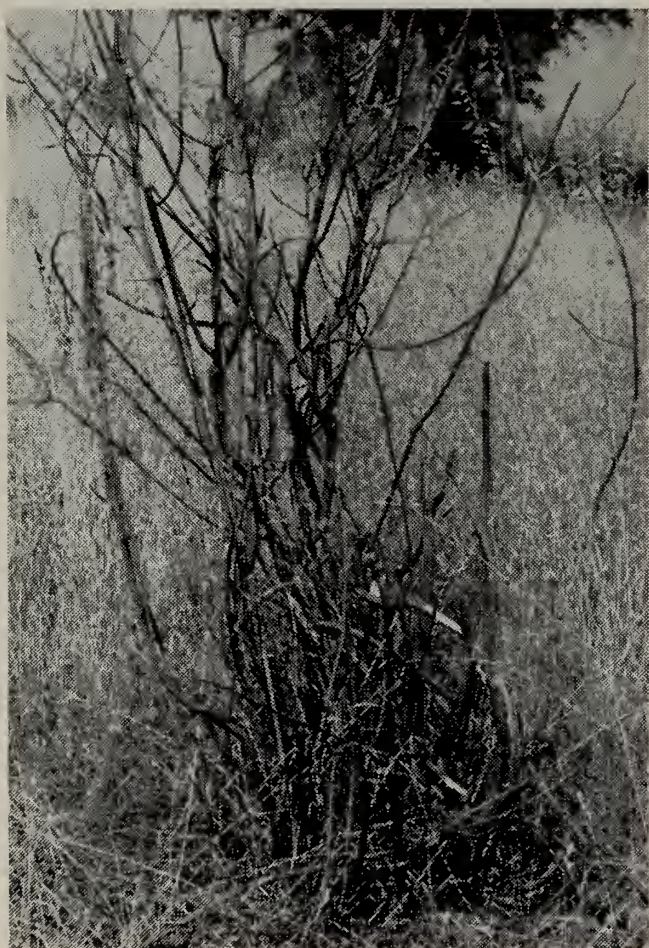
Cattle, sheep, and goats may browse poison oak, but not enough to control it. Actually, heavy browsing by livestock kills competing woody plants, often increasing poison oak stands.

Spray the plants completely to the ground line, including the stems. Poison oak is usually old enough to spray in May in the Sierra foothills, and in May through early July at higher elevations and along the coast. The season for spraying may be slightly extended by adding 1 per cent light emulsifiable summer oil to the spray mixture. One gallon of the mixture will treat five medium-sized clumps.

Basal sprays will kill poison oak almost any time of year, but are most effective during spring and early summer. Their use lessens the chances of damage to nearby ornamental or crop plants sensitive to 2,4-D and 2,4,5-T. Some retreatment will be needed, but less than with foliage sprays. Some isolated sprouts will probably continue to appear for three or four years. For basal sprays see Table D, page 37. Spray enough of the mixture on the lower part of the stems so that some will run off into the soil. Cover sides and base of every stem with the spray. One gallon will treat four medium-sized clumps. Specific dosage recommendations are in Tables A, B, and D.

Water conservation. Increasing the amount of water available for domestic purpose or for irrigation is one of the objectives of woody-plant control. George Wheelwright, of Sausalito, California, has successfully sprayed brush to increase irrigation water.

Riparian vegetation (growing along river banks) should be controlled in areas where water is not adequate. This



Poison oak has been killed by spraying with 2,4-D.

is probably by far the cheapest way of getting water in many water-deficient areas in California. In Arizona, New Mexico, and west Texas, salt cedar is being controlled to increase water for irrigation. In many cases springs can be developed for stock, merely by controlling the trees and brush around them.

It has often been observed that springs start flowing after chaparral and oak woodlands have been burned. It is clear, then, that even non-riparian types of woody plants use water that could appear as spring or well water if these were not present. The quantities of water consumed are very great, but several years' control might be needed to show an increase in the amount of well water.

Wildlife

Some spraying has been conducted recently in Lake County by the California Department of Fish and Game to control sprouting manzanita, since it is not a desirable deer food. The spraying has been done following controlled burns and wild fires. Chemical pruning of browse plants has also been undertaken to make browse more available to wildlife. Brush seedlings may be controlled almost 100 per cent by aircraft spraying in the spring. This may be used sometimes in place of reburning. Late-spring and summer sprays have been reported to be only moderately effective on brush seedlings.

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Table A. Reaction of woody plants to individual treatment with foliage sprays containing 2,4-D and 2,4,5-T.

Common name	Chemical	Lb. actual chemical per 100 gallons	Diluents	Comments
Alder, red.....	brush killer (see p. 38 for definition)	2	Water	High degree of kill is common with one application.
Arrow-weed.....	2,4-D amine	2	Water	Apply 200 gallons spray per acre from April through October.
Blackberry.....	2,4,5-T ester	2-3	Water plus ½ per cent Diesel	Spray after leaves fully expanded and as long as soil moisture adequate for growth. Burn the killed heavy canes. Plan on one or two resprays for complete kill.
Buckeye.....	brush killer	2-3	Water plus ½ per cent Diesel	Spray after leaves fully expanded. Retreatment necessary following year.
Broom, Scotch.....	2,4-D ester	2	Water plus ½ per cent summer oil	Spray while in flower and early seed formation in pods.
Ceanothus (all species).....	2,4,5-T ester	2	Water plus 1 per cent Diesel	Spray while soil moisture is adequate for growth. May also be killed with 2,4-D, but 2,4,5-T generally better.
Chamise.....	brush killer	4	Water plus 1 per cent Diesel	Best from November through May, when soil-moisture conditions are good. For summer and fall spraying, apply the chemicals in Diesel fuel only (and double the concentration of 2,4-D and 2,4,5-T).
Chaparral (whitethorn).....	brush killer	2	Water plus 1 per cent Diesel	Spray after leaves fully expanded in spring and while soil has adequate moisture for growth.
Cherry.....	2,4,5-T ester	4	Water plus 1 per cent Diesel	Spray after leaves fully expanded. One or two retreatments necessary.

Chinquapin bush.....	2,4,5-T ester	4	Water plus 1 per cent Diesel	Two or three applications necessary.
Coffeeberry.....	2,4-D ester	4	Water plus 1 per cent Diesel	Spray after leaves fully expanded and as long as moisture sufficient for growth. One or two resprays necessary. Sensitive in winter and spring also.
Cottonwood.....	brush killer	2-3	Water plus 1/2 per cent Diesel	Spray after leaves fully expanded and as long as leaves are green and healthy. Retreatment necessary.
Coyote brush.....	2,4-D ester or amine	2	Water plus 1/2 per cent summer oil	At all times of year, but best April through July.
Currents and gooseberries..... (Sierra gooseberry, stink currant, mountain pink currant, western black currant, fuchsia flowering currant)	2,4-D ester	1/2-1	Water plus 1/2 per cent summer oil	Thoroughly spray leaves, stems, and bases. Best in period of active growth. See U.S.D.A. Circ. 906, referred to on p. 40.
(Sticky flowering currant, hillside gooseberry, squaw currant, gummy gooseberry, blood currant)	brush killer or 2,4,5-T alone	1-1 1/2	Water plus 1/2 per cent summer oil	Thoroughly spray leaves, stems, and bases. Best in period of active growth.
(Trailing gooseberry, pink flowering currant, white-stemmed gooseberry, prickly currant, flowering currant, hupa gooseberry, canyon gooseberry, mountain gooseberry, Tulare gooseberry)	2,4,5-T ester	2	Water plus 1/2 per cent summer oil	Spray as for other species of Ribes. Use 10 per cent Diesel during post-active season and spray whole plant, with special attention to soaking basal parts.
Deer brush.....	2,4-D ester	1-2	Water	May through July.
Elderberry.....	brush killer	1-2	Water	Spray after leaves fully expanded. Retreatment necessary.

Table A (continued)

Common name	Chemical	Lb. actual chemical per 100 gallons	Diluents	Comments
Gorse.....	2,4,5-T ester	4	Water plus 1 per cent Diesel	Burn. Spray regrowth when two feet tall. Several retreatments necessary.
Hazel.....	2,4-D ester	2	Water	Spray after leaves fully expanded. Two applications may be necessary.
Juniper.....	2,4-D ester	8	Water plus 1 per cent Diesel	Spray when actively growing, or when soil moisture medium or high.
Manzanita, non-sprouting forms	2,4-D ester	4	Water plus 1 per cent Diesel	Best during periods of year when soil is high in moisture.
Manzanita, sprouting forms (greenleaf and eastwood)	2,4-D ester	4	Water plus 1 per cent Diesel	Period of active growth. Probably good rest of year when soil is high in moisture.
Maple, big leaf.....	2,4,5-T ester	2-3	Water	Several repeat applications necessary. Difficult to control by foliage sprays.
Mountain misery..... (or bear clover)	brush killer	2	Water plus 1 per cent summer oil	Spray thoroughly March to early June.
Oak, black.....	brush killer or 2,4,5-T ester	4	Water plus 1 per cent Diesel	Spray sprouts after leaves fully expanded as long as enough soil moisture for growth. A respray necessary for a high degree of kill.
Oak, blue.....	brush killer or propionic brush killer	4	Water, or water plus 1 per cent Diesel	Spray sprouts from May through June or later if soil moisture adequate for growth. Plan on retreatments.
Oak, interior live and coast live	brush killer or propionic brush killer	4	Water plus 1 per cent Diesel	Spray sprouts after leaves fully expanded in spring and as long as moisture is sufficient for growth. October and November sprays have looked good. Some retreatments necessary. Thorough coverage extremely important.

Oak, white live.....	brush killer	4	Diesel	Spray sprouts when actively growing. Easier to kill than interior live oak.
Poison oak.....	brush killer or amino triazole	2-3	Water	Spray after leaves fully expanded and before they begin turning yellow or reddish. Plan on two or more reapplications at yearly intervals. Ammate at $\frac{3}{4}$ lb. per gallon water is effective.
Redbud.....	brush killer	4	Water plus 1 per cent Diesel	Spray after leaves fully expanded in spring. One reapplication necessary.
Redwood.....	2,4-Damine or mixed emulsive acids of 2,4-D plus 2,4,5-T	4	Water plus $\frac{1}{2}$ per cent summer oil	Spray the sprouts in September and possibly later. Some retreatment necessary.
Rose, wild.....	2,4,5-T ester	4	Water plus 1 per cent Diesel	Spray when flowering; retreatments required.
Salt cedar.....	2,4-D amine	2	Water plus 1 per cent summer oil	Spray in May and repeat in June, using drenching sprays.
Thimbleberry.....	brush killer or 2,4,5-T alone	2-3	Water plus 1 per cent summer oil	Spray during periods of active growth. Thorough coverage of whole plant necessary for high degree of kill. Plan on some retreatment.
Toyon.....	2,4-D ester	4	Water plus 1 per cent Diesel	Spray from November through June. Best after a burn. Some retreatment necessary.
Tree of heaven.....	2,4-D ester	4	Water plus 1 per cent Diesel	Several sprayings necessary to eliminate this plant completely.
Willow.....	2,4-D ester	2-3	Water, or water plus 1 per cent Diesel	Spray after leaves fully expanded as long as soil moisture is satisfactory and leaves are green and healthy. Retreatment is necessary and varies with species.

Table B. Reaction of woody plants to broadcast foliage sprays, using ground rigs equipped with a boom or by aircraft.

Common name	Chemical	Lb. actual chemical per acre	Gallons spray per acre	Diluents	Comments
Blue blossom	2,4,5-T ester	2	10	Diesel	Spray after leaves have fully developed—generally June or July.
Ceanothus, general, mature plants	2,4,5-T ester	2-3	5-10	Diesel	One application is generally effective. Spray after leaves have fully developed.
Ceanothus, general, one and two year-old seedlings	2,4-D ester	2	10	Water plus 10 per cent Diesel	Spray after active growth has started but before moisture limits growth.
Ceanothus, San Diego	brush killer	2	5	Diesel	March or April. Growth stages as for the genus.
Ceanothus, bigpod and green-bark	2,4-D ester	3	10	Diesel	As for the genus.
Ceanothus, wedgeleaf	2,4,5-T	2	5	Diesel	As for the genus.
Chamise, one and two year-old sprouts and seedlings	2,4-D ester	2-3	10	Water plus 10 per cent Diesel	Generally best from March through May. Soil moisture important. Best on one-year-old sprouts.
Chamise, sprouts and seedlings older than two years	2,4-D ester	4	40	Water plus 2½ per cent Diesel	Spray when soil moisture high—often November through May. High degree of kill with one application
Chaparral, whitethorn	2,4,5-T ester	3	5	Diesel	As for the genus.
Coyote brush	2,4-D amine	3	10	Water plus 10 per cent summer oil	Best from May through July, but somewhat effective except when soil quite dry. Esters also effective.
Deer brush	2,4-D ester	2	100	Water plus 1 per cent summer oil	After leaves fully expanded.

Deerweed	2,4-D ester	2	10	Water plus 10 per cent Diesel	After leaves fully expanded and while adequate moisture for growth.
Golden fleece	2,4-D ester	2	10	Water plus 10 per cent Diesel	After leaves fully expanded and while adequate moisture for growth.
Greasewood, black	2,4-D ester	2	50	Water plus 2 per cent winter oil	Early summer.
Jim brush	2,4,5-T ester	2	10	Diesel	After leaves fully expanded and while adequate moisture for growth.
Lupine	brush killer	2	10	Water	When flowering.
Manzanita, non-sprouting. Mature plants	2,4-D ester	2	10	Water plus 10 per cent Diesel	Two applications for a high degree of kill. Spray after first leaves fully expanded.
Manzanita, non-sprouting. One and two year-old seedlings.	2,4-D ester	2	10	Water plus 10 per cent Diesel	After growth started in spring but while moisture is high.
Mountain mahogany	brush killer	4	10	Diesel	Burned, and sprouts sprayed next year in June. Retreat the following year.
Oak, scrub	brush killer	4	5	Diesel or summer oil	Burned, and sprouts sprayed in May two years later. Some retreatment necessary.
Poison oak	brush killer	2	10	Water plus 1 per cent Diesel or summer oil	Spray after leaves fully expanded. Reapplication necessary.
Redberry	brush killer	4	10	Diesel	Burned, and sprouts sprayed following year in June. Retreatment necessary.

Table B (continued)

Common name	Chemical	Lb. actual chemical per acre	Gallons spray per acre	Diluents	Comments
Sage, creeping	2,4-D ester	2	10	Water plus 10 per cent Diesel	After active growth starts in spring, while soil moisture high.
Sage, purple and white	2,4-D ester	2	10	Water plus 5 per cent Diesel	After active growth starts in spring, while soil moisture high.
Sagebrush, big, silver, and black	2,4-D ester	2	10	Water plus 5 per cent Diesel or summer oil.	Month of June or after active growth has started (3-4 inches of new twig growth), while soil moisture is high.
Sagebrush, California	2,4-D amine	3	10	Water plus 10 per cent summer oil	April through June, or after active growth has started, while soil moisture is still high.
Snowbrush	2,4-D ester	2	100	Water plus 1 per cent summer oil	After leaves have fully expanded.
Sumac, laurel	2,4-D ester	2	10	Water plus 10 per cent Diesel	Spray two years after a burn in the spring and respray following year.
Toyon	2,4-D ester	3	40	Water plus 2½ per cent Diesel	Spray in the spring, one or two years after a burn (February through May).
Willow	2,4-D ester	4	10	Water plus 2½ per cent Diesel	Spray after leaves fully expanded and as long as soil moisture is adequate for growth and leaves healthy. Species of willow vary greatly in their sensitivity to 2,4-D and amount of retreatment necessary.
Yerba santa	2,4-D ester	2	10	Water plus 10 per cent Diesel	Spray after active growth has begun, but while soil moisture is high. Most sensitive within two years of burn.

Table C. Reaction of woody plants to the cut-surface method using the amine of 2,4-D

Common name	Spacing of cuts	Comments
Buckeye.....	Frill.....	Fill cuts. Late fall to late spring best.
Cottonwood.....	Cuts 6 inches apart.....	Fill cuts. Effective at all seasons.
Madrone.....	Cuts 6 inches apart or frill	Fill cuts. Effective in spring and probably at all seasons.
Oak, black.....	Frill.....	Fill cuts. Effective at all times, but some sprouts will develop on some stumps.
Oak, blue.....	Cuts 6 inches apart.....	Fill cuts. Effective from November through May. Frill if treatments are made in summer and early fall.
Oak, interior, and coast live.....	Frill.....	Fill cuts. Effective at all times, but best from late fall through early spring.
Oak, valley.....	Cuts 6 inches apart.....	Fill cuts. Effective from November through May. Frill for best results in summer.
Pine, digger.....	Cuts every 8 inches.....	Fill cuts. Effective at all times. Probably best results will be obtained in winter and spring.
Willow.....	Frill.....	Fill cuts. Effective at all times.

Table D. Reaction of woody plants to basal sprays.

Common name	Chemical	Lb. actual chemical per 100 gallons	Diluent	Comments
Alder, red	brush killer	16	Diesel	Best results if base chopped into at time of treatment.
Broom, Scotch, and common	brush killer	16	Diesel	Quite sensitive.
Ceanothus	brush killer	16	Diesel	Quite sensitive.
Chamise	brush killer	16	Diesel	Sensitive and readily killed.
Cottonwood	brush killer	16	Diesel	Best results if base chopped into at time of treatment.
Currants and gooseberries	brush killer	16	Diesel	Thoroughly soak bases (crowns) for high degree of control.
Manzanita, non-sprouting forms	brush killer	16	Diesel	Best in late spring and summer, when bark is dry and lower in moisture.
Maple, bigleaf	brush killer	16	Diesel	Good, but high volume spraying necessary, and some retreatment.
Oak, black	brush killer	16	Diesel	Use three fluid ounces for each inch of stem diameter.
Oak, blue	brush killer	16	Diesel	One and one-half to two fluid ounces per inch stem diameter. Effective at all times.
Oak, interior live, coast live, and tan	2,4,5-T ester best, but brush killer will do	16	Diesel	Three fluid ounces per inch stem diameter. Best in spring.

Poison oak.....	brush killer	16	Diesel	Spring and early summer. Reapplications necessary.
Rose, wild.....	2,4,5-T ester	16	Diesel	Thoroughly wet all sides of the stems and crowns. Best when soil has medium moisture content.
Tree tobacco.....	brush killer	16	Diesel	Effective.
Willow.....	brush killer	16	Diesel	Thoroughly wet all sides of the stems and bases. Winter and spring best time for treatment, if area not flooded.

APPENDIX

The following includes the common and scientific names of those woody plants mentioned in tables A, B, C, and D.

Common name	Scientific name	Table under which control is outlined
Alder, red.....	<i>Alnus rubra</i>	A, D
Arrow-weed.....	<i>Pluchea sericea</i>	A
Blackberry.....	<i>Rubus</i> sp.....	A
Blue blossom.....	<i>Ceanothus thyrsiflorus</i>	B
Buckeye.....	<i>Aesculus californica</i>	A, C
Broom, Scotch.....	<i>Cytisus scoparius</i>	A, D
Broom, common.....	<i>Spartium junceum</i>	D
Ceanothus.....	<i>Ceanothus</i> sp.....	A, B, D
Ceanothus, San Diego.....	<i>Ceanothus cyaneus</i>	B
Ceanothus, bigpod.....	<i>Ceanothus megacarpus</i>	B
Ceanothus, greenbark.....	<i>Ceanothus spinosus</i>	B
Ceanothus, wedgeleaf.....	<i>Ceanothus cuneatus</i>	B
Chamise.....	<i>Adenostoma fasciculatum</i>	A, B, D
Chaparral whitethorn.....	<i>Ceanothus leucodermis</i>	A, B
Cherry.....	<i>Prunus</i> sp.....	A
Chinquapin, bush.....	<i>Castanopsis sempervirens</i>	A
Coffeeberry.....	<i>Rhamnus californica</i>	A
Cottonwood.....	<i>Populus</i> sp.....	A, C, D
Coyote brush.....	<i>Baccharis pilularis</i>	A, B
Currants and Gooseberries.....		A, D
Sierra gooseberry.....	<i>Ribes roezli</i>	A
Stink currant.....	<i>R. bracteosum</i>	A
Mountain pink currant.....	<i>R. nevadense</i>	A
Western black currant.....	<i>R. petiolare</i>	A
Fuchsia flowering.....	<i>R. speciosum</i>	A
Hillside gooseberry.....	<i>R. californicum</i>	A
Squaw currant.....	<i>R. cereum</i>	A
Gummy gooseberry.....	<i>R. lobbi</i>	A
Blood currant.....	<i>R. sanguineum</i>	A
Sticky flowering currant.....	<i>R. viscosissimum</i>	A
Trailing gooseberry.....	<i>R. binominatum</i>	A
Pink flowering currant.....	<i>R. glutinosum</i>	A
Prickly currant.....	<i>R. inerme</i>	A
White stemmed gooseberry.....	<i>R. lacustre</i>	A
Flowering currant (loose).....	<i>R. laxiflorum</i>	A
Hupa gooseberry.....	<i>R. marshalli</i>	A
Canyon gooseberry.....	<i>R. menziesi</i>	A
Mountain gooseberry.....	<i>R. montigenum</i>	A
Tulare Gooseberry.....	<i>R. tulareense</i>	A
Deer brush.....	<i>Ceanothus integerrimus</i>	A, B
Deerweed.....	<i>Lotus scoparius</i>	B
Elderberry.....	<i>Sambucus</i> sp.	A
Golden fleece.....	<i>Haplopappus arborescens</i>	B
Gorse.....	<i>Ulex europaeus</i>	A
Greasewood, black.....	<i>Sarcobatus vermiculatus</i>	B

Appendix (continued)

Common name	Scientific name	Table under which control is outlined
Hazel.....	<i>Corylus rostrata</i> var. <i>californica</i> .	A
Jim brush.....	<i>Ceanothus soledatus</i>	B
Juniper.....	<i>Juniperus</i> sp.....	A
Lupine.....	<i>Lupinus rivularis</i>	B
Madrone.....	<i>Arbutus menziesii</i>	C
Manzanita, non-sprouting.....	<i>Arctostaphylos viscida</i>	A, B, D
	<i>A. manzanita</i>	A, B, D
	<i>A. glauca</i>	A, B, D
Manzanita, sprouting.....	<i>Arctostaphylos patula</i> ,.....	A
	<i>A. glandulosa</i>	A
Maple, bigleaf.....	<i>Acer macrophyllum</i>	A, D
Mountain misery or bear clover.....	<i>Chamaebatia foliolosa</i>	A
Oak, black.....	<i>Quercus kelloggii</i>	A, C, D
Oak, blue.....	<i>Quercus douglasii</i>	A, C, D
Oak, interior live	<i>Quercus wislizenii</i>	A, C, D
Oak, coast, live.....	<i>Q. agrifolia</i>	A, C, D
Oak, scrub.....	<i>Quercus dumosa</i>	A, B
Oak, valley.....	<i>Quercus lobata</i>	C
Oak, white live.....	<i>Quercus chrysolepis</i>	A
Oak, tan.....	<i>Lithocarpus densiflora</i>	D
Pine, digger.....	<i>Pinus sabiniana</i>	C
Poison oak.....	<i>Rhus diversiloba</i>	A, B, D
Redberry.....	<i>Rhamnus crocea</i> var. <i>ilicifolia</i>	B
Redbud.....	<i>Cercis occidentalis</i>	A
Redwood.....	<i>Sequoia sempervirens</i>	A
Rose, wild.....	<i>Rosa californica</i>	A, D
Sage, creeping.....	<i>Salvia sonomensis</i>	B
Sage, purple	<i>Salvia leucophylla</i>	B
Sage, white	<i>S. apiana</i>	B
Sagebrush, big,	<i>Artemisia tridentata</i>	B
Sagebrush, black	<i>A. arbuscula</i>	B
Sagebrush, silver	<i>A. cana</i>	B
Sagebrush, California.....	<i>Artemisia californica</i>	B
Salt cedar.....	<i>Tamarix</i> sp.....	A
Snowbrush.....	<i>Ceanothus cordulatus</i>	B
Sumac, laurel.....	<i>Rhus laurina</i>	B
Thimbleberry.....	<i>Rubus parviflorus</i>	A
Toyon.....	<i>Photinia arbutifolia</i>	A, B
Tree of heaven.....	<i>Ailanthus glandulosa</i>	A
Tree tobacco.....	<i>Nicotiana glauca</i>	D
Willow.....	<i>Salix</i> sp.....	A, B, C, D
Yerba santa.....	<i>Eriodictyon californicum</i>	B

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